Long-term follow-up of maxillary fixed retention: survival rate and periodontal health

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Abstract: AIM: To assess the long-term success of maxillary fixed retainers, investigate their effect on gingival health, and analyse the survival rate after a mean period of 7 years (minimum 5 years) in retention. SUBJECTS AND METHODS: Forty one subjects were included in the study A clinical examination of the upper canine to canine region including gingival index (GI), plaque index, probing depth, and bleeding on probing (BOP) was performed. Intraoral photographs and dental impressions were taken and irregularity index was determined and compared to the values of the immediate post-therapeutic values; failures of retainers were also recorded and analysed. RESULTS: The mean observed retention time was 7 years and 5 months. Irregularity index: Changes occurring during retention were statistically different between the lateral incisors bonded to retainers and the canines not bonded to retainers. Only six patients showed changes in irregularity index of the lateral incisors in spite of a retainer in place. Periodontal health: The median value of the GI for all teeth bonded to upper retainers was 1.10 and the median value of the plaque index (PI) was 1.14. PI was not a significant predictor of GI. The overall BOP of the bonded teeth to the retainer for each participant was 22.3 per cent. Failure rate: Twenty-eight out of 41 patients experienced no failure of the upper bonded retainer (68.3 per cent). Detachments were the most frequent incidents. CONCLUSION: Although plaque accumulation might be increased in patients with already poor oral hygiene, maxillary bonded retainers caused no significant negative effects on the periodontal health.

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Original article

Long-term follow-up of maxillary fixed retention: survival rate and periodontal health

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Summary

Aim: To assess the long-term success of maxillary fixed retainers, investigate their effect on gingival health, and analyse the survival rate after a mean period of 7 years (minimum 5 years) in retention.
Subjects and Methods: Forty one subjects were included in the study A clinical examination of the upper canine to canine region including gingival index (GI), plaque index, probing depth, and bleeding on probing (BOP) was performed. Intraoral photographs and dental impressions were taken and irregularity index was determined and compared to the values of the immediate post-therapeutic values; failures of retainers were also recorded and analysed.
Results: The mean observed retention time was 7 years and 5 months. Irregularity index: Changes occurring during retention were statistically different between the lateral incisors bonded to retainers and the canines not bonded to retainers. Only six patients showed changes in irregularity index of the lateral incisors in spite of a retainer in place. Periodontal health: The median value of the GI for all teeth bonded to upper retainers was 1.10 and the median value of the plaque index (PI) was 1.14. PI was not a significant predictor of GI. The overall BOP of the bonded teeth to the retainer for each participant was 22.3 per cent. Failure rate: Twenty-eight out of 41 patients experienced no failure of the upper bonded retainer (68.3 per cent). Detachments were the most frequent incidents.
Conclusion: Although plaque accumulation might be increased in patients with already poor oral hygiene, maxillary bonded retainers caused no significant negative effects on the periodontal health.

Introduction

Anterior teeth alignment following orthodontic therapy represents one of the treatment outcomes, which are susceptible to change (1). Ten years after orthodontic treatment dissatisfactory alignment of anterior teeth can be found in 40–90 per cent of orthodontic patients (2) and according to Little *et al.* (3), only 10 per cent of all cases have clinically acceptable mandibular alignment up to 20 years post-retention. Retention is therefore essential in order to maintain alignment of anterior teeth after orthodontic treatment.

The appliances used for retention are either removable or fixed retainers. Since the performance of removable appliances depends on patient compliance, fixed retainers were introduced to provide a reliable and successful means to minimize relapse tendency. Apart from variations in size and wire types, the multistranded bonded lingual retainer introduced by Zachrisson (4) constitutes one of the standard types of retainer configuration utilized.

The current literature lists a wide range of studies investigating the effects of lingually bonded fixed canine-to-canine retainers on oral health. Thus, fixed retainers have been examined after 3 years

of service (5), or following a minimum of 9 years (6) and even after a minimum of 20 years (7). These studies have shown that long-term retention of mandibular incisors with a fixed retainer had no negative effects on teeth or periodontal health.

Previous studies have also shown that the main benefit of bonded retainers is the prevention of relapse and that they are a reliable form of retention (5,8–10). The foregoing analysis is only valid when the retainers themselves exert no active forces, and therefore a reliable technique for fixed retainer manufacturing and bonding is essential to achieve passivity of the wire and to prevent undesirable side-effects (11–12) The overall spatial parameters in the maxilla are different compared with the mandibular retainers because of less saliva wetting in the former as well as less rigidity because of a longer wire span in the maxillary arch. Since maxillary retainers are bonded to each tooth, they may have a different effect on periodontal health due to complex cleaning requirements. In addition to that, the greater amount of bonding interfaces may expose them to more failures than mandibular retainers. This could be exaggerated by the occlusal forces they are subjected to during mastication. Only few studies (12–14) have evaluated the possible failures and the effect on periodontal health of fixed retainers in the maxillary arch (15). As a result of their different clinical set-up data from previous studies referring to mandibular retainers cannot be transferred to maxillary retainers.

Therefore, the aims of this retrospective study were to assess the long-term success of upper bonded retainers to counteract relapse, to investigate their effect on gingival health and analyse the survival rate after a minimum of 5 years in retention.

Subjects and methods

The investigation was based on a selection of 50 consecutive patients called up for routine annual examination following orthodontic therapy at the Department of Orthodontics and Paediatric Dentistry of theUniversity of Zurich. Inclusion criteria were: at least 5 years in retention with a fixed bonded retainer in the maxilla; orthodontic treatment performed at the Department; complete orthodontic records available; participants' age between 20 and 30 years of age.

The assessed retainers were fabricated of a stainless steel alloy with the dimensions of 0.016 × 0.016 inches (Figure 1).

The study protocol was submitted to the local Ethics Committee and permission for conducting the procedures was received. Informed consent was obtained from all participants and all examinations of the participants were performed by the same investigator, consisting of dental impressions to obtain plaster casts and a clinical periodontal examination of the upper canine to canine region at least 5 years into retention.

Figure 1. Clinical appearance of a representative retainer assessed in the present study.

The following variables were assessed:

1. On the dental casts, the irregularity index (16) for incisors and canines was determined (t_1) and compared to the values of the immediate post-therapeutic casts taken at debonding (t_0).
2. Plaque Index (PI) (17) on the buccal and palatinal surfaces was evaluated using a disclosing agent (paro plak®, Profimed AG, Kilchberg, Switzerland) and plaque accumulation was categorized with the following scale:

   0: no plaque detectable
   1: small plaque formation
   2: band-like deposits of plaque (without covering the interdental space)
   3: visible deposits, covering also the interdental space

Mean values for all six maxillary teeth (canines and front teeth) were calculated for each subject.

3. Gingival index (GI) (18) was estimated for each tooth on the buccal and palatinal surface according to the following scale:

   0: normal gingival
   1: small inflammation with a slight discoloration, little edema, no bleeding on palpation
   2: moderate inflammation with redness, edema and bleeding on probing (BOP)
   3: severe inflammation with pronounced redness and edema, ulcerations and tendency to spontaneous bleeding

The mean value of all surfaces was calculated and the grade of gingival inflammation was defined as followed:

   0,1-1: mild gingival inflammation
   1,1-2: moderate gingival inflammation
   2,1-3: severe gingival inflammation

4. Probing depth (PD), defined as distance from the gingival margin to the most apical part of the sulcus, was measured at 6 locations for each tooth (mesio-/mid-/disto-buccal and mesio/mid-/disto-palatal) with a PP 12DMS Perititan-Probe (Deppeler, Rolle, Switzerland).
5. BOP (19) was measured in conjunction to PD at 6 locations for each tooth and noted either positive (bleeding) or negative (no bleeding).
6. The clinical records of each participant were studied in regard to the retention period and searched for incidents such as loose retainers, wire fractures or even total loss of the retainer.

Statistics

Out of the initial 50 consecutive follow-up patients who were willing to participate, 9 patients had to be excluded, since they did not match the inclusion criteria (e.g., younger or older in age or incomplete records). Thus, the statistical evaluation was performed on 41 participants (25 females, 16 males) with fixed retainers in the maxilla. In regard to changes in the irregularity index, each patient served as own control group, and the lateral incisors (bonded to retainers) were compared to the canines (without retention). Three patients had to be excluded from this investigation, because their retainers were bonded to the canines, too. Descriptive analysis was performed on all obtained values and the assumption of normality was investigated with the Kolmogorov–Smirnov test.

A Mann–Whitney *U*-test was applied to the differences in irregularity index between the retained lateral incisors and the un-retained canines. Median values of PI and GI within each participant were calculated, the Pearson correlation coefficient was performed to evaluate a possible correlation between PI and GI, and median regression was applied to investigate if PI is a significant predictor of GI. PD and BOP were recorded and averaged for all teeth bonded to the retainer. Incidents of failures, their timing and causes were described and the survival rate of the retainers was investigated; the statistical significance was set at 0.05.

Results

The mean observed retention time between t_0 (end of active treatment/begin of retention) and t_1 (at least 5 years in retention) was 7 years and 5 months (median: 7 years and 3 months; min.: 5 years and 2 months; max.: 11 years and 7 months).

Irregularity index

The descriptive values for the irregularity index at debond (t_0), in retention (t_1) and for the differences that occurred during retention (t_1–t_0) are presented in Table 1 and Figure 2. The Kolmogorov–Smirnov test demonstrated that these values did not follow normal distribution. Mann–Whitney *U*-test indicated that the changes occurring during retention was statistically highly different between the lateral incisors bonded to retainers and the canines not bonded to retainers ($P < 0.001$). Only six patients showed changes in irregularity index of the lateral incisors in spite of a retainer in place, but 33 out of 38 patients had an unfavourable change in irregularity of the un-retained canines.

Table 1. Irregularity index (mm) of lateral incisors bonded to retainer and canines not bonded to retainer.

Irregularity index	Mean	±1 SD	Min	Max
Lateral incisors (n = 38)				
At debond (t_0)	0.27	0.30	0.00	1.20
In retention (t_1)	0.27	0.41	0.00	2.40
Difference (t_1–t_0)	0.00	0.25	−0.90	1.20
Canines (n = 38)				
At debond (t_0)	0.49	0.39	0.00	2.00
In retention(t_1)	0.94	0.63	0.00	2.60
Difference (t_1–t_0)	0.45	0.51	−0.60	2.00

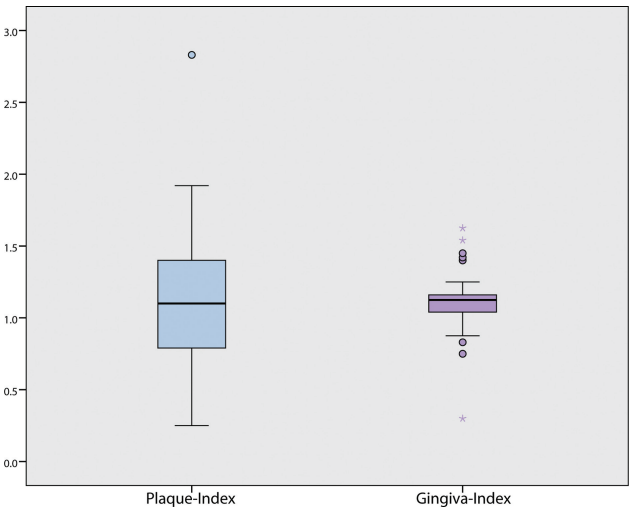

Figure 2. Box-and-whisker plot for changes in irregularity index from debond (t_0) up to at least 5 years into retention (t_1) for laterals boned to retainers and canines not bonded to retainers (n = 38).

Periodontal health

At least 5 years into retention (t_1), the median value of the GI for all teeth bonded to upper retainers was 1.10 (IQR: ±0.13; min.: 0.30;

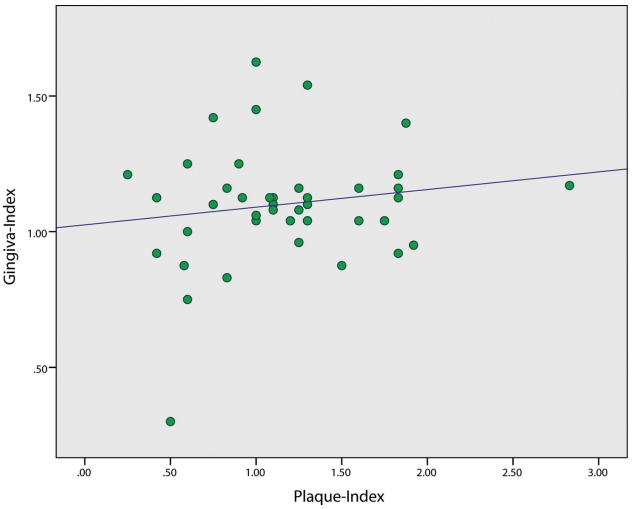

Figure 3. Box-and-whisker plot for plaque index and gingival index of all cases at least 5 years in retention (n = 41).

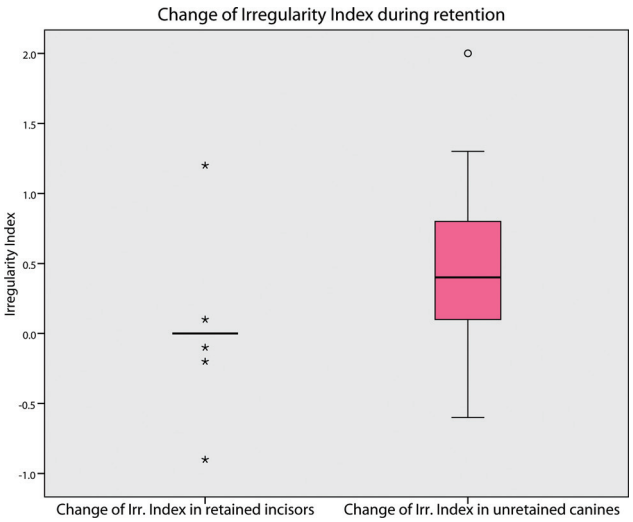

Figure 4. Distribution of cases (n = 41): gingival Index value plotted against plaque index value. Blue line corresponds to the fitted values.

Table 2. Median regression to investigate if plaque index is a significant predictor of gingival index.

Gingival index	Coeff.	SE	t	$P > \|t\|$	95% confidence interval	
Plaque index	0.029	0.052	0.56	0.580	−0.077	0.136
Const.	1.086	0.066	16.31	0.000	0.952	1.22

max.: 1.63) and of the PI was 1.14 (IQR: ±0.80; min.: 0.25; max.: 2.83; Figure 3).

A possible association between PI and GI was investigated and for every subject, PI was plotted against GI (Figure 4). Kolmogorov–Smirnov test demonstrated no statistical difference to normality (PI: 0.61; GI: 0.20). Pearson correlation coefficient of PI and GI was low (r = 0.16) and PI was not a significant predictor of GI (b = 0.03, 95 per cent confidence interval:–0.08, 0.14, P = 0.58; Table 2).

Forty six per cent of the patients had at least one periodontal site with a PD of more than 3 mm, but the overall BOP of the bonded teeth to the retainer for each participant was 22.3 per cent (median: 19.0 per cent; min.: 6.0 per cent; max: 61.0 per cent).

Failure rate

Total number of incidents, their time of occurrence after debonding and the nature of the incident are given in Table 3. Twenty-eight out of 41 patients experienced no failure of the upper bonded retainer (68.3 per cent). Seven patients had 1 failure, 4 patients 2 failures, and 2 patients even experienced 3 retainer failures. Of all incidents (20), detachments were the most frequent type with 18 occurrences (85.7 per cent). Disregarding detachments and considering only serious failures, results in 38 patients (92.8 per cent) showing no evidence of retainer failure. The Kaplan–Meier survival estimate of all observed retainers is given in Figure 5.

Discussion

Irregularity index

Without any retention, a high relapse especially in the alignment of the mandibular arch can be anticipated after orthodontic treatment (3,21–27). This relapse can also be awaited for in the maxillary anterior region if no retention is conducted. Quaglio *et al.* (28)

Table 3. Incidents to retainer: number of incidents, time of occurrence, and nature of incident.

Patient	Total incidents	Time of incident No.1 (months)	Time of incident No.2 (months)	Time of incident No.3 (months)	Nature of incident
1	0				
2	1	3			Fracture
3	0				
4	0				
5	0				
6	2	0	3		Detachment (2×)
7	1	22			Detachment
8	2	27	49		Detachment (2×)
9	2	33	51		Loss due to accident/detachment
10	0				
11	0				
12	0				
13	0				
14	0				
15	0				
16	0				
17	3	10	12	22	Detachment (3×)
18	0				
19	1	95			Detachment
20	1	7			Detachment
21	2	32	58		Detachment (2×)
22	0				
23	1	86			Detachment
24	0				
25	0				
26	1	60			Detachment
27	0				
28	0				
29	0				
30	0				
31	0				
32	3	75	123	127	Total loss/detachment (2×)
33	0				
34	0				
35	0				
36	0				
37	0				
38	0				
39	0				
40	1	40			Detachment
41	0				

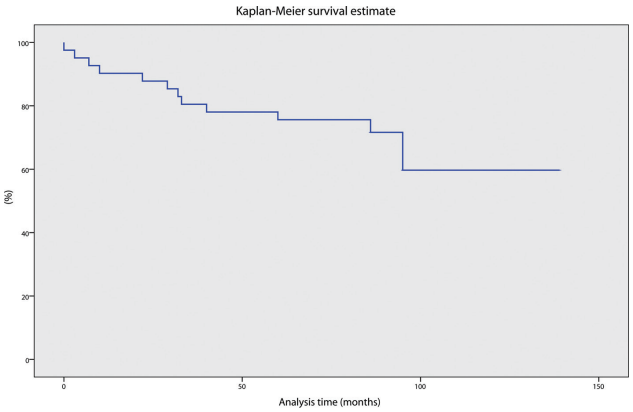

Figure 5. Kaplan–Meier survival estimate demonstrating the failure rate of the 41 observed retainers. Incidents listed in Table 3 were considered failures of survival, even though most of them consisted of detachments and were re-bonded.

demonstrated that stability of anterior alignment after treatment and with no retention was high over the long term, but there was a high tendency of relapse to the original position of the tooth. Our findings demonstrated that, with the maxillary retainer in place, change in irregularity index within the incisors was low with only six patients having a change in irregularity index. Since the fixed retention did not include the canines, this was the region most susceptible to changes and actually served as a control to identify potential anterior dental arch changes outside of retainer viscinity; in fact, changes in the irregularity index at the canine region were noted in 33 out of 38 patients (87 per cent; Figure 6). Previous studies concluded that the mandibular lingual flexible coaxial wire retainer bonded on all anterior teeth is more effective in maintaining the alignment than the thick mandibular lingual retainer bonded only on the canines (29–32).

Periodontal health

Previous studies have revealed that fixed retainers could have a negative effect on periodontal health due to increased plaque retention and BOP (15). Compared with removable retainers, bonded fixed retainers have been shown to increase plaque and calculus accumulation but a similar limited gingival inflammation was found in the presence of both types of retainers (16). Therefore the increased plaque accumulation does not seem to have detrimental effects on the integrity of the dental hard tissues adjacent to the wire (33).

Since the GI defines the grade of inflammation and since plaque is the main reason for gingivitis, we expected a correlation between PI and GI. Median value of the GI was 1.10, corresponding to a mild inflammation. The median value of the PI for all teeth bonded to upper retainers was 1.14. Both values can be compared to the findings of Lang and Engelmayer who examined Swiss soldiers age 28–32 years where mean PI was 1.38 and mean GI was 1.11 (34). In a more recent study, a total of 626 Swiss Army recruits were examined and PI, GI and PD were assessed. The mean PI and GI were 1.33 and 1.23, a value slightly higher than the one reported in this study (34). Overall, there was no association between PI and GI in the patients followed in this study. The use of historial data as opposed to baseline data for the patients included in the study derives from the potential inappropriateness of comparing periodontal indices of patients at an adolescent age (at t_0) with ages well into adulthood (t_1). Thus, apart from practicality reasons relating to following the periodontal health indices of patients 5-1 years post debonding, the onset of habbits such as smoking, could influence the periodontal

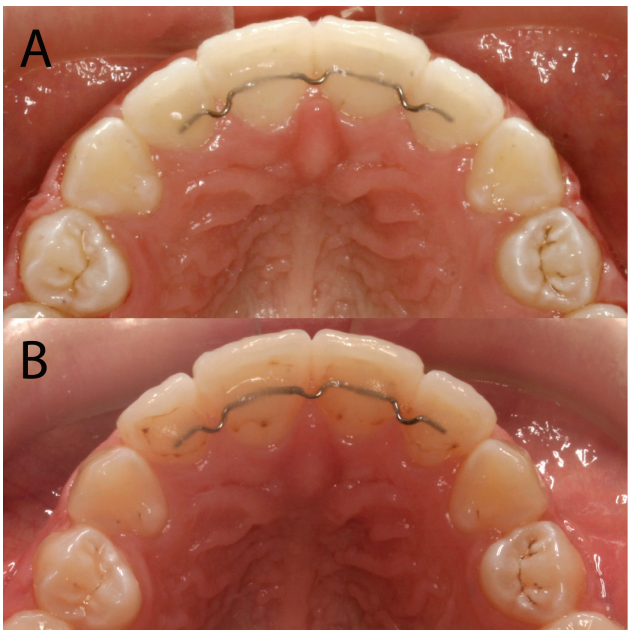

Figure 6. Clinical appearance of a maxillary lingual fixed retainer (A) at debonding, and (B) 2 years 2 months into retention of same patient. Note the arch alteration occuring in the area of canines.

health more than the variable examined in the study (retainer). Similar practices have been followed in other long-term monitoring studies of retainers (6).

Overall BOP of the teeth bonded to the retainer for each participant was 22.3 per cent. This corresponds to values of previous studies assessing the prevalence of gingival bleeding in adults with no fixed retention where median BOP was 22.5 per cent (35–37). Compared to these values, BOP in patients followed in this study was fairly low. Additionally, 46 per cent of the patients had at least one periodontal site with a PD of more than 3 mm. Increased PD was also found when comparing mandibular anterior teeth in a long-term retention group (mean period of 9.65 years) with a short-term retention group (period of 3–6 months) (6).

Failure rate

Bond failures of the lower retainer are estimated to range between 6 and 22.9 per cent (12,37,14). Most studies had a shorter observation period and therefore a reduced amount of failures were prone to occur within the defined retention time. Lumsden *et al.* (13) suggested that maxillary retainers do break more often than lower retainers. Moreover, in the present study, the maxillary retainers were bonded by postgraduate students and the operator experience might have been affected the overall rate of failure (14). The nature of incidents included fractures, detachments and loss due to accident. The interpretation of Kaplan–Meier–Diagram implies that the risk of failures might be higher during the first 3 years of retention. Nevertheless, even after a long retention period of 127 months, failures may also occur.

The configuration and type of wires selected for the fabrication of fixed retainers might have an effect on failure rate. Bonding failures within wires bonded on all teeth might lead to increased irregularity more often than with stainless steel wires attached only to the canines. Renkema *et al.* (30) stated that this might be due to the time lapse between the actual and reported failures in canine-to-canine fixed retention because bonding failures are often

unnoticed whereas with the bar retainer bonded only on the canines the patient immediately senses detachments. Other disadvantages associated with fixed retention are attributed to the potential for tooth movement due to lack of passivity of the wire or distortion within the flexible wires (11). Unexpected complications occur while using flexible spiral wires such as torque differences between adjacent teeth or increased buccal inclination and movement of canines (10).

Conclusions

- Maxillary bonded fixed retainers seem to cause no significant negative effects on the periodontal health despite a slight increase in plaque accumulation.
- Maxillary bonded retainers have fairly high survival rates.

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